WIND ELECTRIC POWER STATION

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16. Abstract

A wind power station is described in which the structure on which the rotors are mounted may tilt as wind speed changes, so that the rotors leave the vertical plane to anticipate increased wind speeds. The power station may have pulse generators located in front of the turbine rotors on extensions of the turbine shaft or on separate booms under the turbine; winches to tilt the turbine platform, normally locked by means of a brake, which is released when a predetermined wind thrust is reached; flexible tension members to transmit the thrust of the wind to the nontilting portion of the structure; provisions to change the direction of the winches as wind speed changes; an auxiliary vane to control an electrically driven propeller to rotate the power plant into the wind; and auxiliary generators to be used when wind speeds are too low for normal synchronous operation.

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WIND ELECTRIC POWER STATION

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This invention relates to wind electric power stations that generate electricity with large double-rotor tilting turbines on high towers. Wind power stations are known which generate electrical power with two turbine rotors rotating in opposite directions operating on a rocker with which they adjust themselves at an incline relative to the direction of the wind. These known wind power plants have rotors of different diameter which are difficult to control and jeopardize the stability of the power station. These power stations deliver unregulated current which is unsuitable for the consumers and must have recourse to external auxiliary power. The shifting of wind rotor weights on the rocker was not adapted to power generation and required a considerable additional outlay in power involving losses in yearly energy production. These disadvantages are avoided in this invention. The moments of inertia of the tilting portion of the power station are compensated for on the rocker with the torques exerted on the tilting portion by wind forces. The tilt angles of the tilting portion are adjusted to wind velocities by means of a regulating system controlled by electrical pulses in such a manner that power and axial thrusts remain constant and all overloads are prevented. The acceleration of air masses, i.e. gust strength as a function of its duration, has been determined on the basis of research which has been accomplished, and a speed assigned to the mechanical tilt-angle control system which is higher than the acceleration of the air masses, so regulation is more rapid than acceleration of the air masses. Tilt speed is regulated in this invention by electrical pulses from a wind sensor, namely from a generator in front of the turbine which is operated by its own turbines and which sets a normally braked electrically driven winch in motion once wind velocities corresponding to the rated power of the power station

/1* (beside line 1) ... /2 (beside "normally braked electrically driven winch in motion once wind")

*Numbers in the margin indicate pagination in the foreign text.

are reached and exceeded. The same current of air which is utilized for power generation is also used to regulate power in order to prevent generator overloads, the axial thrusts also being kept constant so that the stability of the power station is not jeopardized. The power spent on regulation is kept small because turbine thrust, with its torques in the leeward direction, is overcome by the weight-induced torques of the tilting section in the windward direction.

The wind blowing at the tower of the power station is assumed to have a maximum value of 45.6 m/s, in accordance with building codes, the tower absorbing about 500 tons of force. The turbine of the wind-driven electric power station fully utilizes all wind strengths, including storms, but its maximum power is restricted to the full utilization of wind speeds up to 15 m/s by the tilt limit. At higher wind speeds, tilting is initiated, so only a component of the wind is operant and power is kept constant with it. At wind speeds higher than 15 m/s, output thus remains constant at 2000 m/s for a single-unit wind power station, and thrust is limited to 240 tons. If a wind speed of 45.6 m/s, for which the tower is designed, were also operant in the turbine, an output of about 56,000 m/s would be obtained. I.e., output would increase by a factor of 28 and call for an economically unfeasible generator. Wind thrust on the turbine would rise from 240 to 2200 tons, and total wind pressure on the power station would increase from 740 to 2700 tons, thereby threatening the stability of the tower. These dangers are eliminated by the mechanical tilt-angle control system in this invention; operation and stability are always assured.

The power station can then also deliver three-phase power of the same frequency in parallel operation with the grid. The generator's falling out of phase is prevented by the tilt-angle control system in this invention. Due to the dependence of frequency upon turbine speed for a given number of poles, the full utilization of wind speeds has a lower limit in parallel operation with the grid, and lower wind speeds would therefore remain unutilized. During separate operation, of course even weak winds would also be made use of. In order to likewise include wind strengths below the synchronization point with this invention during parallel operation, auxiliary pulse generators and auxiliary power generators are cut in which are operated by the roller bearing system of the turbine rotors. According to experiments, the large rotors begin to turn at wind speeds of 1.5 to 2 m/s. The speeds of the secondary power generators are sufficient to deliver power at 3 to 3.5 m/s wind speed, so operation from 3 to 6.5 m/s can also frequently be included and made additional use of. These secondary generators also impart a relatively high degree of reliability to the power supply to the electrical systems for mechanical tilt-angle control. They operate synchronously and can aid in excitation of the primary machinery. The wind sensor, serving as a pulse generator for tilt-angle control, operates, in this invention, at a distance in front of the turbine which corresponds to a multiple of the distance traveled by the wind per second associated with the rated power so that control of the electrical pulses is initiated before the altered wind currents reach the turbine. Since an extension of the turbine shaft which changes its direction with the tilt angle of the tilting section serves as the mount for the wind sensor, the mount is inclined at about 30° toward the ground so that it is in a horizontal position when the turbine is inclined 30° and has a 30° upward inclination when the turbine has moved to a 60° inclination. The wind sensor is thereby still at a sufficient distance from the turbine in the most frequent positions.

Should the electric control system for the tilt mechanism malfunction, the turbine would then rock freely at wind speeds exceeding rated power and assume an inclination which is determined by the angle of tilt associated with that wind speed. The leeward tilting moments due to wind thrust overcome the windward moments due to the wind rotor masses. The windward tilt point in the normal position is located in front of the instantaneous center of rotation of the tilting section on its rocker. If the wind thrust acting upon the tilting section overcomes the weight-induced moment of the tilting section relative to the center of rotation, a linkage system which is connected with the brake on the winch is released by unloading of the windward tilt point, as a result of which the brake is released and the winch is enabled to tilt the tilting section.

The increasing tension in the tension members of the rocker guide system can also be utilized via pulleys and levers to release the winch brake. Electrical disturbances stop excitation and thus the production of power by the generator, so overloads are prevented even in the case of malfunctions.

The wind power station, with its turbines, is kept facing the wind by means of a tail in the conventional manner. If the center of a storm low passes over the power station, a not infrequent occurrence, wind direction can change 180° in just a short period without the tail fulfilling its job. In this invention, rotation into the new wind direction is accomplished with an auxiliary wind indicator which controls an electrically driven propeller whose thrust rotates the power station about the vertical axis of the tower and keeps it in the proper position by switching off.

Figure 1 shows the wind electric power station with dual turbines K, their blades 3 and 5, generator 4, turbine shaft A, /3
and rocker M, mounted on tower T by means of rotating framework G. Rotating framework G is held by bearings 23 and 24. Shaft A carries wind sensor C, with measurement instruments D, on extension B. In this invention, wind sensor C can also operate on a boom 22 held into the wind by rotating framework G. Tail F on boom E is used to

steer the power station into the wind with the aid of auxiliary vane J, switching flap L and auxiliary propeller H. Winch N is used to tilt the tilting section with tension members O on pulleys P. Column 26, with auxiliary generator 27, is located to the lee of the tilt point of rocker M to compensate for the weight-induced moments of the power plant.

Auxiliary generator 27 serves as an exciter unit for primary generator system K, i.e. generator 4. The former operates synchronously in the air current of the primary machinery; its outputs correspond to the requirements of the primary machinery and thereby prevent falling out of phase. The auxiliary generator produces direct current. Since failure of the auxiliary generator disturbs power generation by the primary machinery, secondary generators are able to go into operation in this invention, either a small series turbine or DC units 32 driven by rollers 30. A last reserve is represented by the generator of wind sensor D, which, as a pulse generator, has only to supply small energy levels but which, with a suitably dimensioned separate turbine, provides enough power that a battery can be charged as an exciter reserve.

If the power plant assumes the horizontal position, such as for testing, the wind sensor, with its generator, can continue to operate freely in the wind. It is equipped with cup rotors which continue to operate at a low u/v even in the strongest gales.

Figure 2, p.10, shows the dual turbine with blades 3 and 5, plus generator 4, in the vertical operating position;

Figure 3 shows the same turbine in the horizontal position on rocker path R;

Figure 4 shows the curve of angle of tilt as a function of wind speed and that of the moments M_M of the gyrating masses, dependent upon the rate of tilt;

Figure 5 shows the additional windward moments M_G of inherent weights and the opposing leeward moments M_W due to wind thrust. The hatched area indicates the excess moments resulting from wind thrust. The rate of tilt must be controlled on the basis of these in such a manner that tilting is more rapid than acceleration of the air masses.

Figure 6 shows the curve of braking work required during the rocker's return travel;

Figure 7, p. 12, shows a cross section through shaft A, with the configuration of turbine bearing rollers 30 and the hubs of rotors 3 and 5;

Figure 8 represents an enlarged transverse view of the transmission assembly by which rollers 30 drive auxiliary generator 32 via gear 31;

Figure 9 is a section through rocker path R, with rocker M on the tilting section, which is connected with the rocker path via tension members W, which transmit wind thrust to the rocker path;

Figure 10 is a partial section through the supporting framework of rocker path R, which transmits the vertical loads to tower T via tilting joints 33 and guideways 34, in whose place disk bearings can also be used. Tower T carries slip rings 36 at its top for delivering electrical power.

Horizontal forces are transmitted via rollers 35, which are mounted at 23 and 24 in Fig. 1.

Tension members W, which are located right under the rocker rail and are connected to the rocker at the leeward end and to the rocker paths at the windward end, must be distinguished from the tension members O in Fig. 1, by means of which rocker M is actuated by means of winch N.

Claims

1. Wind electric power station with power regulation via tilting of the wind turbines, characterized in that the tilting motion occurs ahead of acceleration of the masses of air acting upon the wind turbines.

2. Wind electric power station in accordance with Claim 1, characterized in that the pulse generators controlling tilting are mounted on extensions of the turbine shaft which curve toward the ground at about 30° or on supporting structures which are held into the wind with the framework that supports the rocker path, and these pulse generators operate at a distance in front of the turbine rotors which is greater than the distance traveled by the wind per second when the power station is delivering its rated output.

3. Wind electric power station in accordance with Claims 1 and 2, characterized in that contrarotating turbine rotors of equal dimensions are used which in their normal position are located in front of the tilt point of the rocker.

4. Wind electric power station in accordance with Claims 1 through 3, characterized in that winches with tension members, rigidly braked in the normal position, are used to tilt the tilting section.

5. Wind electric power station in accordance with Claims 1 through 4, characterized in that wind thrust on the tilting section is transmitted to the rocker path through flexible tension members.

6. Wind electric power station in accordance with Claims 1 through 5, characterized in that controls which release the brakes on the winches used to tilt the tilting section are actuated by removal of the load on a step bearing at a predetermined wind thrust on the tilting section.

7. Wind electric power station in accordance with Claims 1 through 6, characterized in that the direction of rotation of the /4 winches changes as a function of the rising or falling of wind speed in such a manner that the motion of the tilting section is always in the opposite direction.

8. Wind electric power station in accordance with Claims 1 through 7, characterized in that the power plant is steered into the direction of the wind by an auxiliary control vane which controls an electrically driven propeller whose thrust rotates the power plant into the direction of the wind.

9. Wind electric power station in accordance with Claim 2, characterized in that the pulse generators are also used for excitation of the turbine generator.

10. Wind electric power station in accordance with Claims 1 through 9, characterized in that generators which are driven by the roller bearing system of the turbine hubs are provided in case of need for the purpose of utilizing wind speeds lower than those corresponding to synchronous operation.

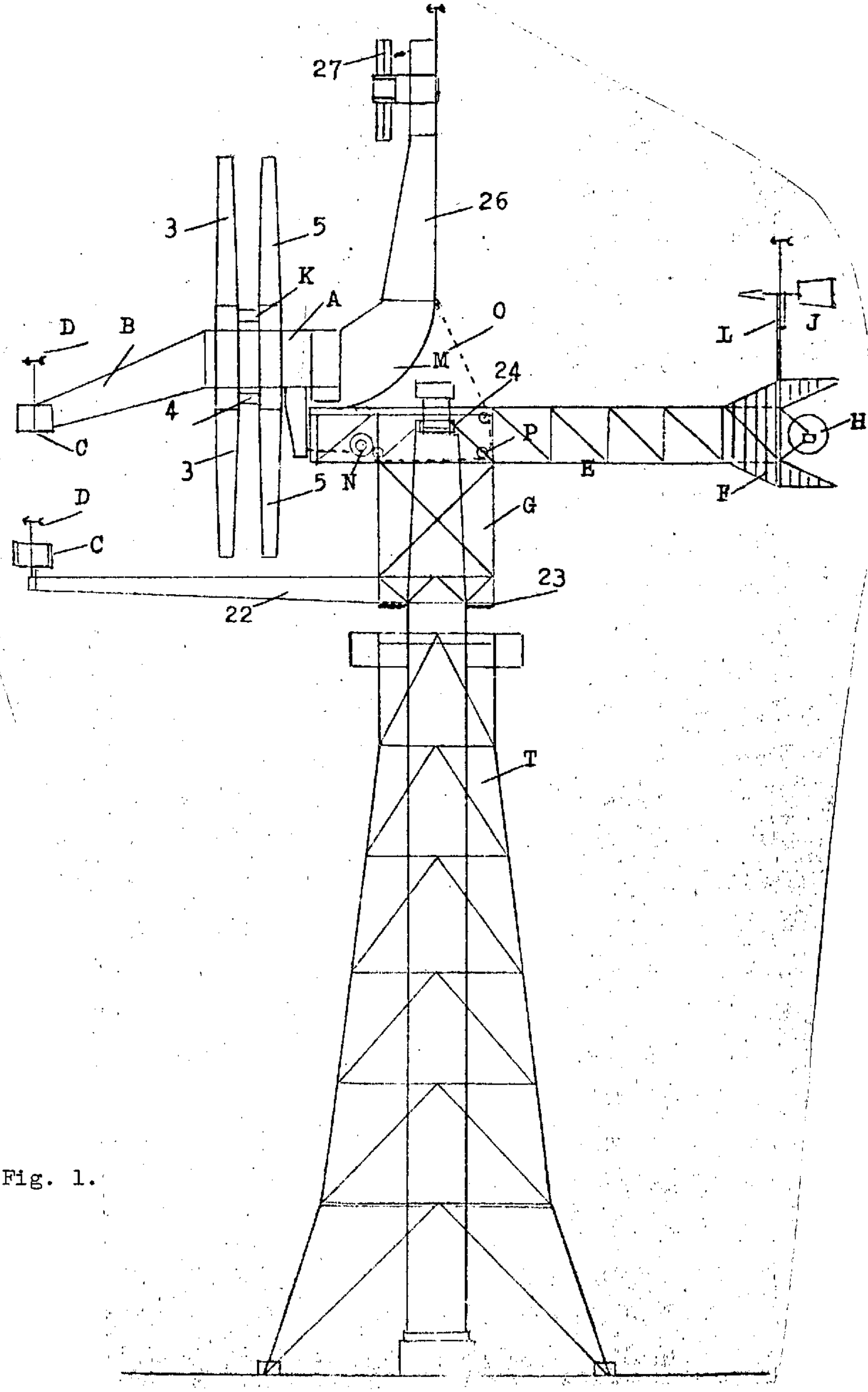


Fig. 1.

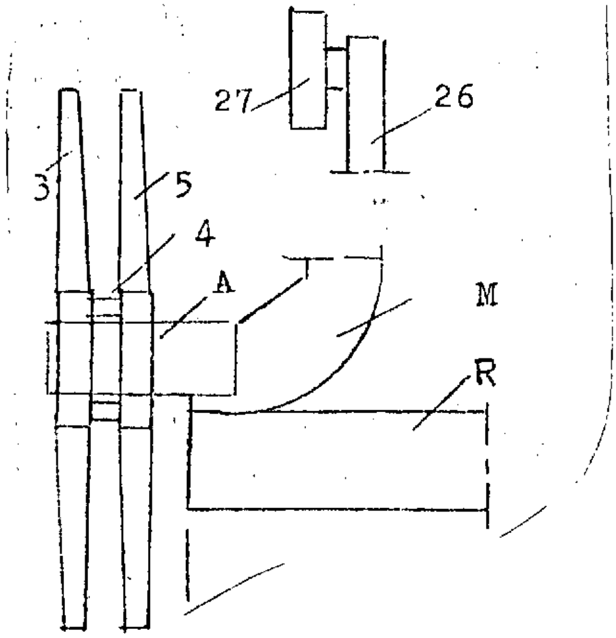


Fig. 2.

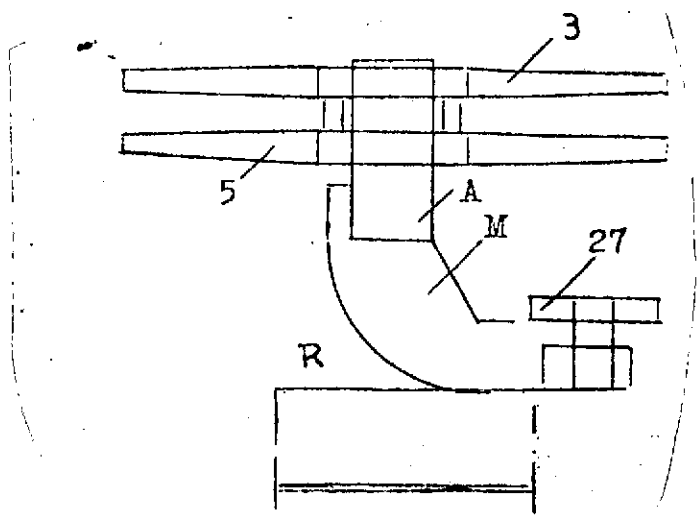
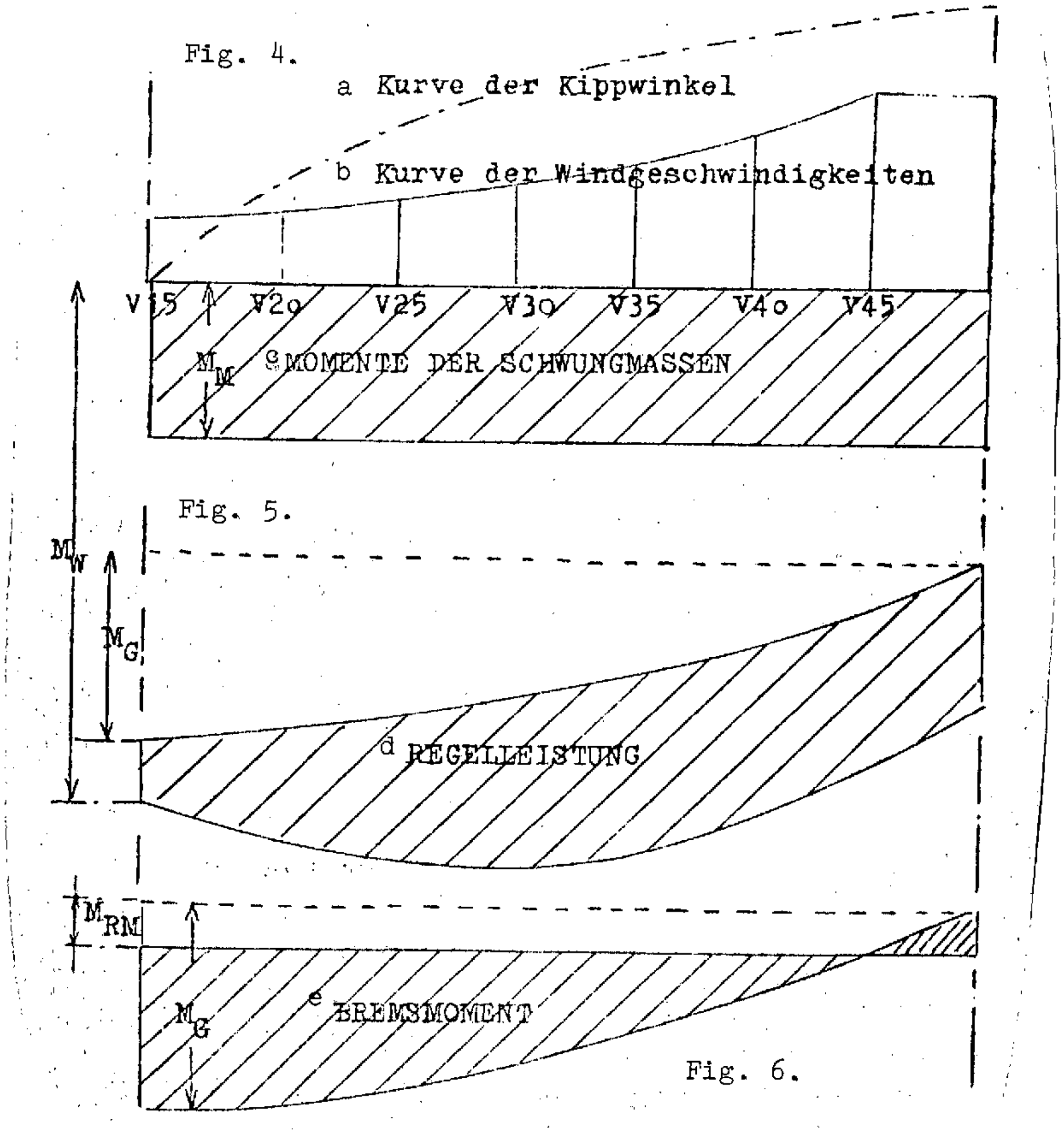


Fig. 3.



Key: a. Curve of tilt angles
b. Curve of wind speeds
c. Moments of gyrating masses
d. Control power
e. Braking torque

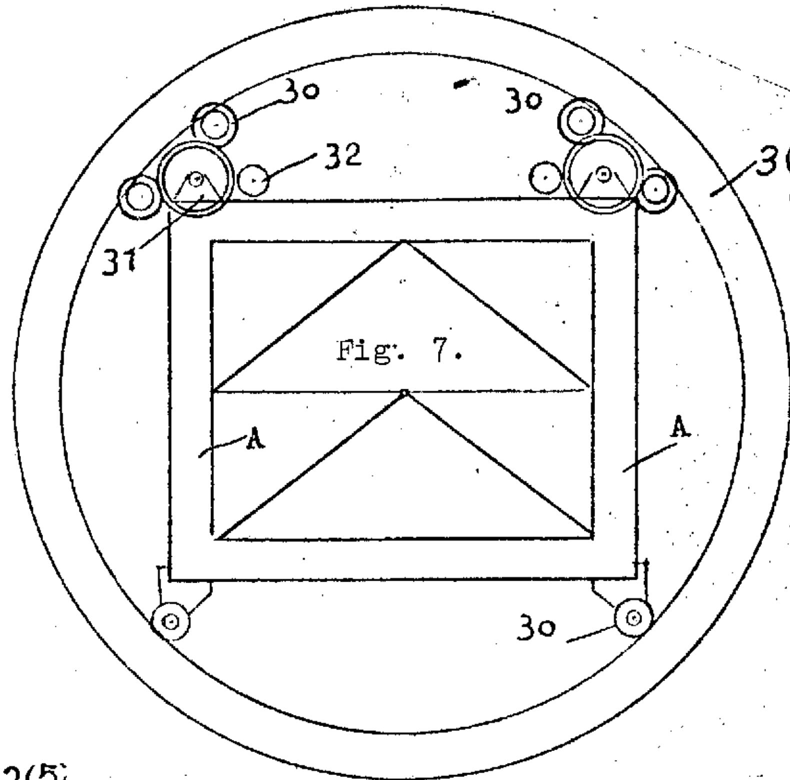


Fig. 7.

Fig. 8.

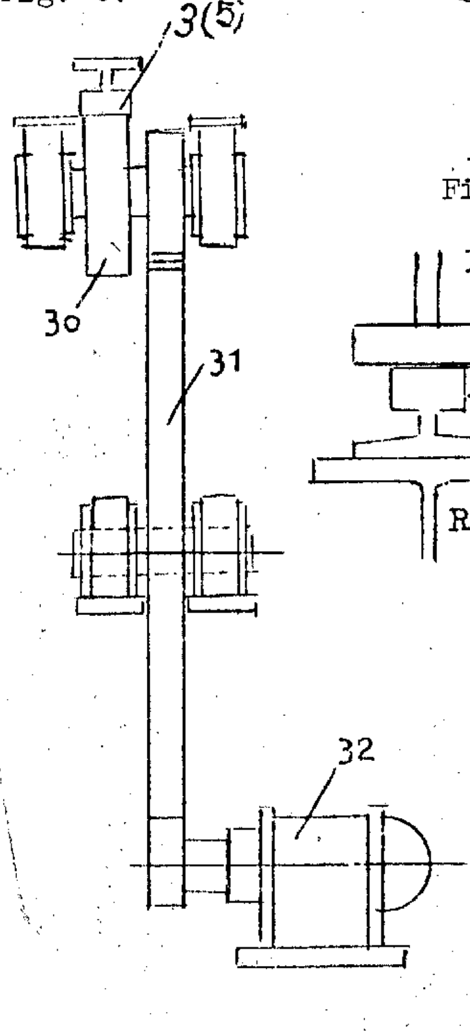


Fig. 9.

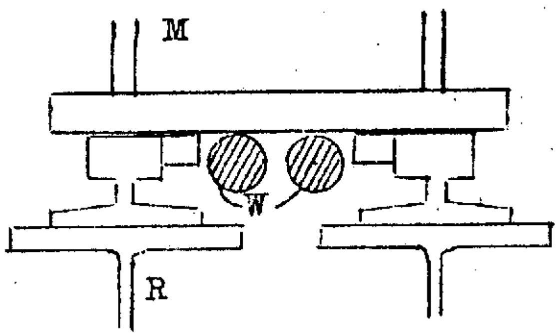


Fig. 10.